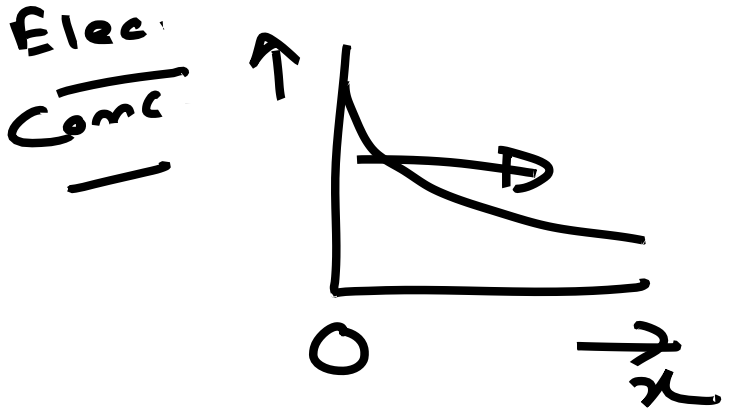
# Movement of carriers

Two processes:

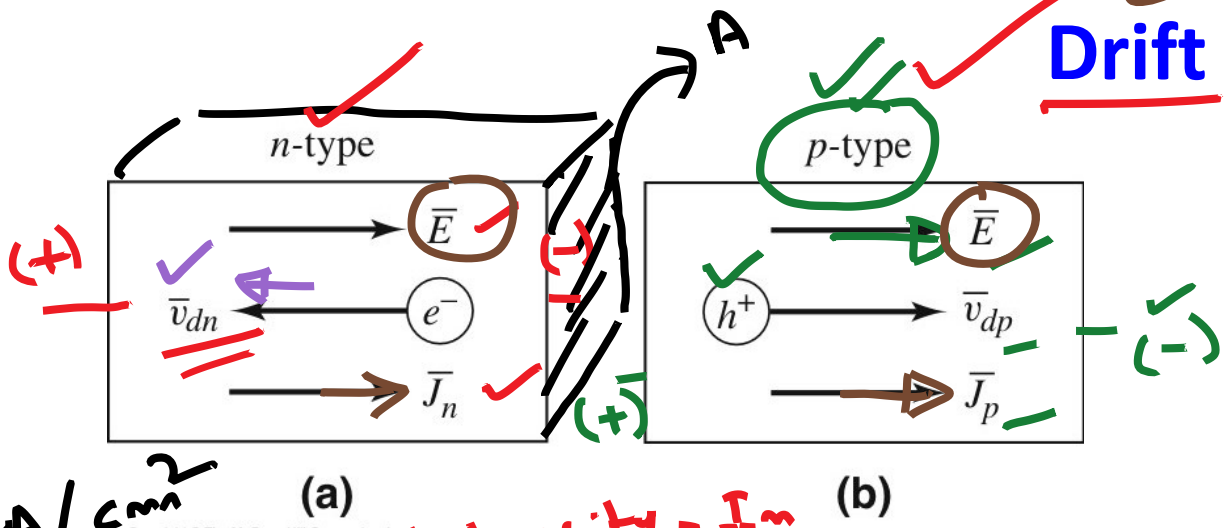
① Drift → Electric field

② Diffusion → Concentration gradient




Source: Electronic circuits: Analysis and Design –by D. A. Neamen, McGraw-Hill

# Drift Current






$A/cm^2$

current density $= \frac{I_m}{A}$

$J_m = -nq v_{dn}$ ; n = conc. of electrons

q = charge of n

$v_{dn}$ = drift velocity

$\mu_n$ = mobility of electron 'Si'

$v_{dn} \propto E$

$v_{dn} = -\mu_n E$

$J_p = pq v_{dp}$

$v_{dp} = \mu_p E$

$\mu_n = 1350\ cm^2/V\text{-}S$

$\mu_p = 450 - 500\ cm^2/V\text{-}S$

* $J_n = nq\mu_n E$

The drift currents associated with the electrons and holes are in the same direction.

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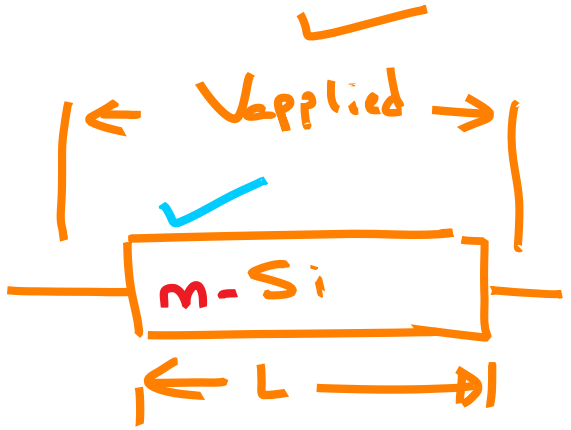
# Drift Current




$E = \frac{V_{applied}}{L}$

Total drift current = $J_n + J_p$ (A/cm²)

$= nq\mu_n E + pq\mu_p E$

$= (nq\mu_n + pq\mu_p)E = (nq\mu_n + pq\mu_p)\frac{V_{applied}}{L}$

$= \sigma E$

Conductivity $\sigma$ ($\Omega^{-1}$-cm$^{-1}$) $= nq\mu_n + pq\mu_p$

m-Si, donor conc = $N_d \gg n_i$

$n \cong N_d = 10^{15}\ cm^{-3}$ $\quad 10^{15}\ cm^{-3}$

$p = \frac{n_i^2}{n} = 2.25 \times 10^5\ cm^{-3}$

$\sigma = nq\mu_n + pq\mu_p$

$\sigma \cong N_d q\mu_n$

$N_d: 10^{15} \rightarrow 10^{18}$

$\sigma \rightarrow$ increase by $10^3$

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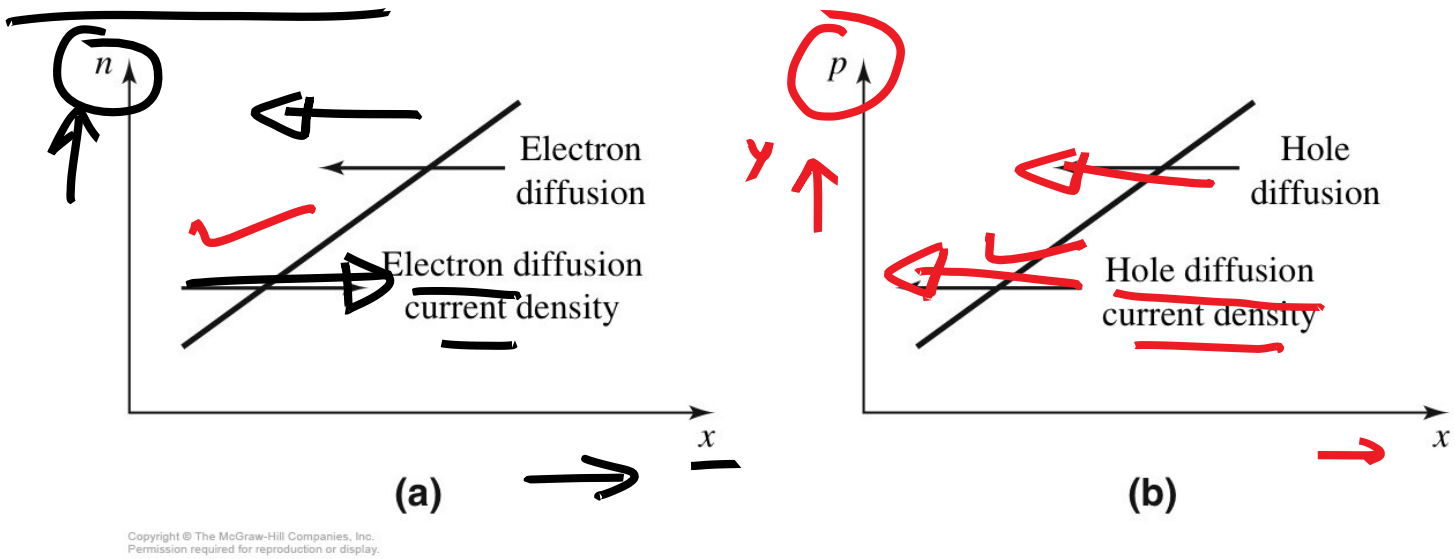
# Diffusion Current

$$J_n = qD_n \frac{dn}{dx}$$

$$J_p = -qD_p \frac{dp}{dx}$$






Both electrons and holes flow from high concentration to low.

The diffusion current associated with the electrons flows in the opposite direction when compared to that of the holes.

**Source:** Electronic circuits: Analysis and Design –by D. A. Neamen, McGraw-Hill

# Diffusion Current

$$J_n = q D_n \frac{dn}{dx} \qquad J_p = -q D_p \frac{dp}{dx}$$

mobility ($\mu$)

$$\frac{D_n}{\mu_n} = \frac{D_p}{\mu_p} = \frac{kT}{q} = V_T$$

[Einstein Relation]

Thermal voltage, $T = 300\,K$, $V_T \approx 26\,mV$

Total current

$$J_{n\text{-total}} = J_{n\text{-drift}} + J_{n\text{-diff}} = n q \mu_n E + q D_n \frac{dn}{dx}$$

$$J_{p\text{-total}} = p q \mu_p E - q D_p \frac{dp}{dx}$$

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